

MILLIMETER WAVELENGTH OBSERVATIONS OF SOLAR FLARES FOR MAX'91

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BIMA Array

The Astronomy Program of the University of Maryland has recently joined the Universities of California (Berkeley) and Illinois in a consortium to upgrade the Hat Creek millimeter-wave interferometer (to be known as the Berkeley-Illinois-Maryland Array, or BIMA). The improved array (see below) will become available during the coming Solar Maximum, and we will have guaranteed time for solar observing as part of the consortium. We plan to make quasi-dedicated observations for long periods (10-15 days at a time), depending on solar activity.

The Hat Creek millimeter interferometer presently consists of three 6-m diameter antennas which can be located at various stations along a T-shaped road-way which extends 300 m East-West and 200 m North-South. Current operation is in the 2.5 - 4 mm wavelength atmospheric window. The receivers employ cooled Schottky diode mixers. The receivers can be tuned by a solid state oscillator from 70 to 115 GHz. Retuning takes about 5 - 15 minutes. Both sidebands of the first mixer are received and are separated by phase switching of the local oscillators. Thus, two frequencies separated by 2.3 GHz can be observed simultaneously. One linear polarization is received. A quarter-wave plate to produce circular polarization around 90 GHz is available. The receiver, antenna and atmosphere contribute to the the system temperature. Scaled to above the atmosphere, the temperature is typically 300 to 500 K SSB over most of the band, rising to about 1000 K at 115 GHz where the opacity is greater.

The BIMA consortium has decided to expand this interferometer into a 6-element array with 15 baselines. Work is already in progress for this expansion, and it is expected to be complete in 2 years time. This array with 15 baselines will permit us to produce synthesized snapshot maps of solar flares simultaneously at 4 frequencies in the range 70 - 240 GHz. Thus, not only will the positions of mm burst sources be known, but their spectra will also be determined with reasonable accuracy. Before this expansion is completed, however, we shall use the instrument as a 3-element interferometer. This will be useful to find the positions of strongest burst sources with temporal resolution $\gtrsim 0.1$ sec. We shall be able to make these measurements at 2 frequencies separated by 2.3 GHz.

Science Objectives

The millimeter region has been perhaps the most under-utilized observing wavelength range in solar physics, due to the lack of telescopes which can match the temporal and spatial resolution available at other wavelengths. Millimeter wave observations are sensitive to both the highest-energy electrons in flares as well as to cool material in the chromosphere.

The science we shall address divides naturally into flares and chromospheric structures. Highly energetic particles accelerated in flares radiate strongly at millimeter wavelengths: in particular, since gamma-ray imaging is presently difficult, a millimeter array is the only method of imaging the most energetic particles in flares, and we propose many important studies using this fact. Using high-time-resolution, we will study particle acceleration in the impulsive phase, and the location of acceleration region in relation to other flare features. We hope to add greatly to the understanding of prompt acceleration in flares using temporal and spatial resolution previously unavailable. Delays between gamma-ray and millimeter peaks will be studied in conjunction with spatial information on the location of the millimeter sources, which, along with information in microwaves, will allow us to investigate the propagation of energy from the corona to the chromosphere during the impulsive phase. And we will establish whether gamma-rays and millimeter-waves come from identical regions by studying the anisotropy of millimeter-wave flares on the disk.

Observations of structures in the chromosphere outside of flares will place more emphasis on mapping, particularly of filament depressions and sheaths, the brightness distribution at the limb, and of active region structure. Millimeter waves can investigate the interface between filaments and the corona, the understanding of which is essential to model filaments. We will identify fine structures which we expect to find and relate them to spicules and interspicular regions inferred from limb brightness distributions. We will seek to confirm reports that coronal holes appear bright at millimeter wavelengths, and study the reason for this. Using mosaicing techniques we will map active regions and study the correspondence of optical, magnetogram and millimeter features. Finally, measurement of circular polarization will allow us to measure magnetic fields in the chromosphere.

PATROL MONITORING OF THE SUN AT MILLIMETER WAVELENGTHS

After its extension to six-elements the BIMA Array will have a seventh antenna available. This antenna, already equipped with 2-4 mm receivers, can be used for monitoring the Sun. It may be possible to use this antenna for fully dedicated observations of the Sun at a number of other wavelengths, e.g. 2 cm, 1 cm, 4mm and 2 mm. This arrangement will provide us with spectra at high frequencies not at present routinely available.

Daily monitoring of solar continuum flux at four wavelengths: 20mm, 10mm, 3mm, and 1.3mm. The receiver is located near the vertex of a 6m diameter antenna, as shown in Figures 4 and 5 below, for two different possible resolutions. In Figure 4 the receiver observes the entire sun directly with large beams at all wavelengths. In Figure 5 mirrors are inserted so that the sun is observed with the resolution of the 6m antenna (see table). Time resolution is ≥ 0.1 sec, permitting the study of flare development.

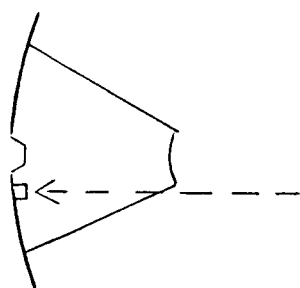


Figure 4

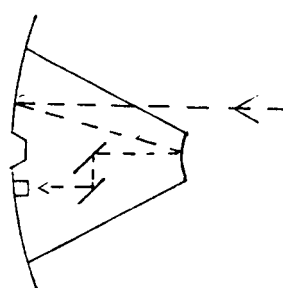


Figure 5

WAVELENGTH	RESOLUTION	
	<u>1</u>	<u>2</u>
20mm	30'	12'
10mm	30'	6'
3mm	30'	2'
1.3mm	30'	1'

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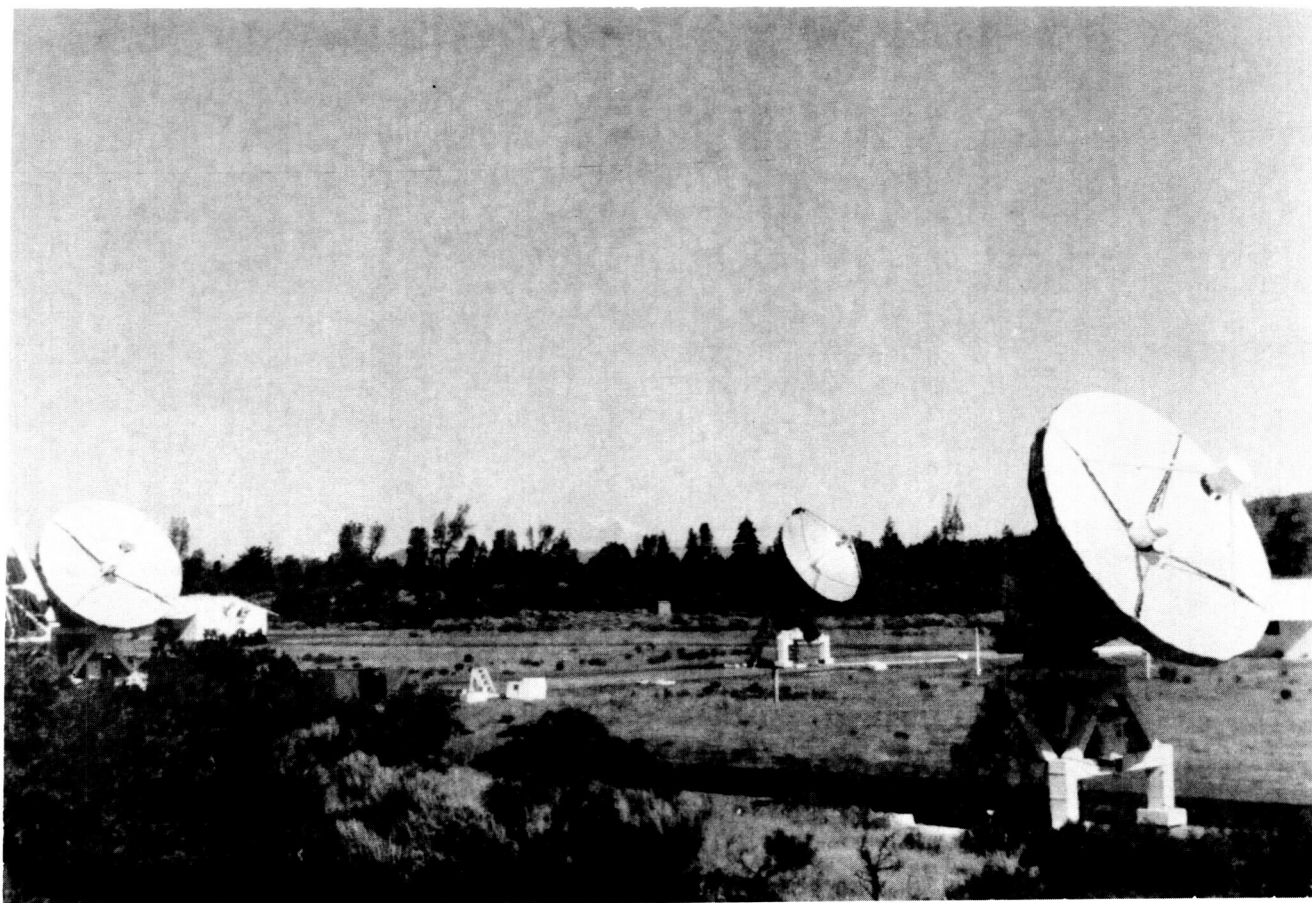


FIG. 1. THREE ELEMENT INTERFEROMETER PRESENTLY
AVAILABLE FOR SOLAR OBSERVATIONS AT MILLIMETER
(2-4MM) WAVELENGTHS. THE ARRAY IS SCHEDULED
TO BE COMPLETED BY EARLY 1991.

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FIG. 2. A SCHEMATIC DIAGRAM OF THE SIX-ELEMENT
BIMA ARRAY FOR MILLIMETER WAVELENGTH OBSERVATIONS
OF THE SUN (SEE TEXT).

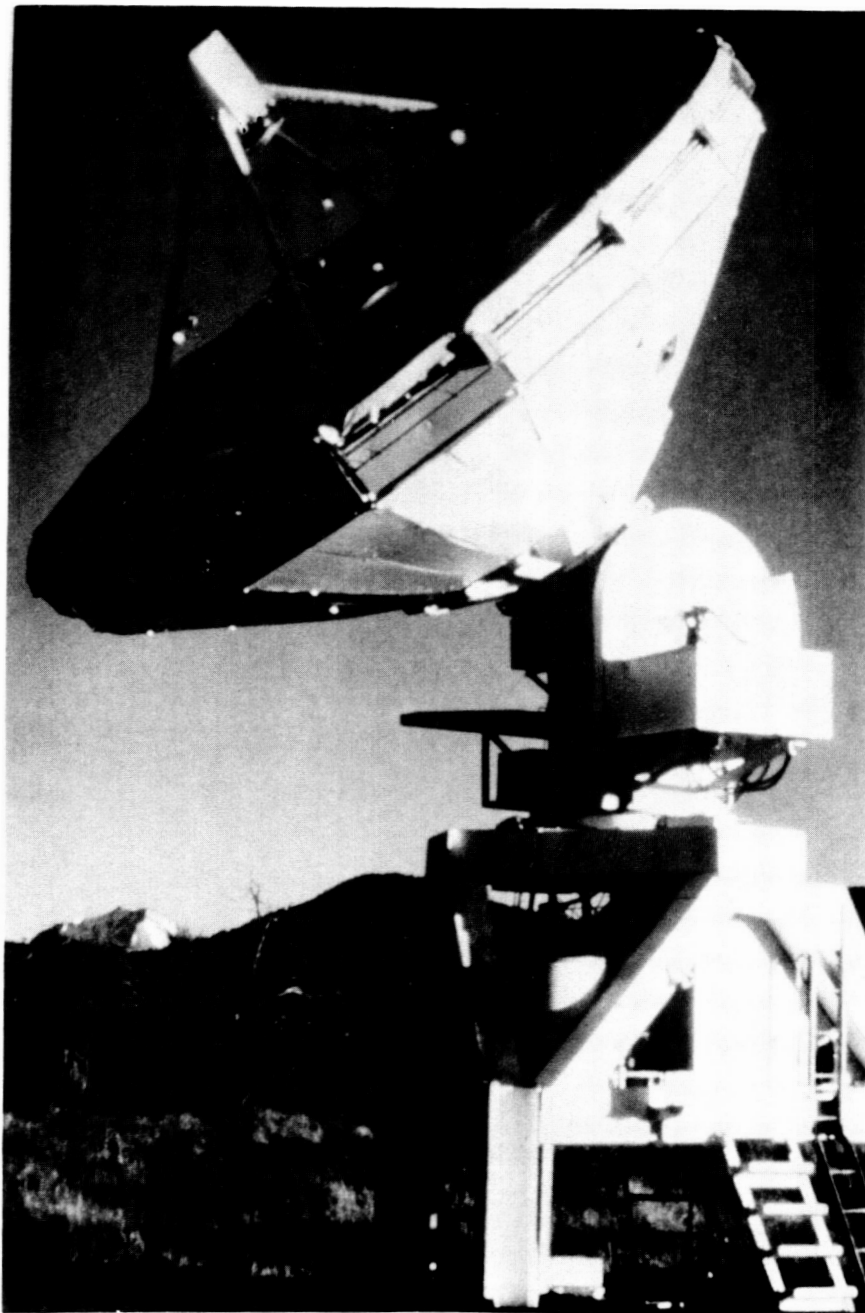


FIG. 3. THE SEVENTH ANTENNA OF THE BIMA ARRAY TO
BE USED FOR DEDICATED OBSERVATIONS OF SOLAR
FLARES AT FOUR WAVELENGTHS IN THE 20 - 1.3 MM
RANGE.